

PCT

**CHAPTER I**

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AUTHORITY (IPEA/US)**

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METHOD AND SYSTEM FOR PROVIDING DYNAMIC MODELING AND RECIPE  
OPTIMIZATION OF SEMICONDUCTOR ETCH PROCESSES  
TITLE OF INVENTION

Tokyo Electron Limited  
APPLICANT

**International Bureau of WIPO  
34 chemin des Colombettes  
1211 Geneva 20, Switzerland**

**ARTICLE 19 AMENDMENT**

Dear Sir:

Please amend the international application to include the attached replacement sheet(s) (21-27), in place of originally filed sheets 21-22. The replacement sheets represent amendments made to the claims. Specifically, please note that existing claims 1-7 have not been amended, claims 8-13 have been amended, and new claims 14-39 have been added as provided on the enclosed replacement sheets 21-27. The abstract is now on page 27.

Respectfully submitted,

Date:

11/17/03

Sanjeev K. Dutta  
Sanjeev K. Dutta  
Reg. No. 46,145

12400 Wilshire Boulevard, 7th Floor  
Los Angeles, California 90025-1026  
(408) 947-8200

## CLAIMS

What is claimed is:

1. A method, comprising:

modeling an etch process used in semiconductor manufacturing to generate a dynamic process model;

using the dynamic process model to determine input parameters that meet a desired output parameter; and

optimizing a process recipe for the etch process with the input parameters.

2. The method of claim 1, wherein the etch process is a cell formation process.

3. The method of claim 1, wherein the dynamic process model is a linear ARX model with input nonlinearities.

4. The method of claim 1 wherein the optimized process recipe improves cell sidewall profiles.

5. The method of claim 4, wherein the optimized process recipe incorporates a maximum allowable number of recipe steps as an explicit process constraint.

6. The method of claim 4, wherein the optimized process recipe incorporates a maximum allowable input value as an explicit process constraint.

7. The method of claim 4, wherein the optimized process recipe incorporates a minimum allowable input value as an explicit process constraint.

8. The method of claim 1, wherein modeling an etch process, comprises:

using a non-linear model structure;

paramaterizing one or more memoryless non-linear functions associated with the non-linear model structure;

deriving a linear model from the non-linear model structure;

identifying a bias value for one or more input parameters and one or more output parameters;

generating a dynamic spatial model of the one or more output parameters, wherein the one or more input parameters in a time domain relate to the one or more output parameters in a spatial domain;

predicting one or more future output parameters when one or more test input parameters are provided to the linear model; and

optimizing the one or more output parameters using the linear model.

9. The method of claim 8, wherein the dynamic spatial model is a deposition rate model.

10. The method of claim 8, wherein the one or more input parameters include:

one or more dopant gas flows including TriEthyl Borate, TriEthyl Phosphate, and TetraEthyl OrthoSilicate; and

one or more plasma etch inputs including pressure, power, and gas flows.

11. The method of claim 8, wherein the one or more output parameters include one or more chemical vapor deposition outputs including Secondary Ion Mass Spectrometry dopant profiles before and after reflow, Fourier Transform Infrared Spectroscopy aggregate dopant profiles, plasma etch outputs, and wet clean outputs including electrical measurements, critical dimension measurements, Scanning Electron Microscopy cross-section sidewall profiles before and after wet etch in both X and Y directions.

12. The method of claim 1, further comprising manufacturing a semiconductor wafer with cell profile deviations less than 100 angstroms.

13. The method of claim 8, wherein the non-linear model structure is an INARX model, wherein the memoryless non-linear functions capture dynamic etch process behaviors.

14. A system, comprising:

means for modeling an etch process used in semiconductor manufacturing to generate a dynamic process model;

means for using the dynamic process model to determine input parameters that meet a desired output parameter; and

means for optimizing a process recipe for the etch process with the input parameters.

15. The system of claim 14, wherein the etch process is a cell formation process.

16. The system of claim 14, wherein the dynamic process model is a linear ARX model with input nonlinearities.

17. The system of claim 14, wherein the optimized process recipe improves cell sidewall profiles.

18. The system of claim 17, wherein the optimized process recipe incorporates a maximum allowable number of recipe steps as an explicit process constraint.

19. The system of claim 17, wherein the optimized process recipe incorporates a maximum allowable input value as an explicit process constraint.

20. The system of claim 17, wherein the optimized process recipe incorporates a minimum allowable input value as an explicit process constraint.

21. The system of claim 14, wherein modeling an etch process, comprises:

means for using a non-linear model structure;

means for parameterizing one or more memoryless non-linear functions associated with the non-linear model structure;

means for deriving a linear model from the non-linear model structure;

means for identifying a bias value for one or more input parameters and one or more output parameters;

means for generating a dynamic spatial model of the one or more output parameters, wherein the one or more input parameters in a time domain relate to the one or more output parameters in a spatial domain;

means for predicting one or more future output parameters when one or more test input parameters are provided to the linear model; and

means for optimizing the one or more output parameters using the linear model.

22. The system of claim 21, wherein the dynamic spatial model is a deposition rate model.

23. The system of claim 21, wherein the one or more input parameters include:  
one or more dopant gas flows including TriEthyl Borate, TriEthyl Phosphate, and TetraEthyl OrthoSilicate; and  
one or more plasma etch inputs including pressure, power, and gas flows.

24. The system of claim 21, wherein the one or more output parameters include one or more chemical vapor deposition outputs including Secondary Ion Mass Spectrometry dopant profiles before and after reflow, Fourier Transform Infrared Spectroscopy aggregate dopant profiles, plasma etch outputs, and wet clean outputs, wherein the wet clean outputs include electrical measurements, critical dimension measurements, and Scanning Electron Microscopy cross-section sidewall profiles before and after wet etch in both X and Y directions.

25. The system of claim 14, further comprising means for manufacturing a semiconductor wafer with cell profile deviations less than 100 angstroms.

26. The system of claim 21, wherein the non-linear model structure is an INARX model, wherein the memoryless non-linear functions capture dynamic etch process behaviors.

27. A computer readable medium, having stored thereon computer-readable instructions, which when executed in a computer system, cause the computer system to perform:

modeling an etch process used in semiconductor manufacturing to generate a dynamic process model;

using the dynamic process model to determine input parameters that meet a desired output parameter; and

optimizing a process recipe for the etch process with the input parameters.

28. The computer-readable medium of claim 27, wherein the etch process is a cell formation process.

29. The computer-readable medium of claim 27, wherein the dynamic process model is a linear ARX model with input nonlinearities.

30. The computer-readable medium of claim 27, wherein the optimized process recipe improves cell sidewall profiles.

31. The computer-readable medium of claim 30, wherein the optimized process recipe incorporates a maximum allowable number of recipe steps as an explicit process constraint.

32. The computer-readable medium of claim 30, wherein the optimized process recipe incorporates a maximum allowable input value as an explicit process constraint.

33. The computer-readable medium of claim 30, wherein the optimized process recipe incorporates a minimum allowable input value as an explicit process constraint.

34. The computer-readable medium of claim 27, further having stored thereon computer-readable instructions, which when executed in the computer system when modeling an etch process, cause the computer system to perform:

- using a non-linear model structure;

- paramaterizing one or more memoryless non-linear functions associated with the non-linear model structure;

- deriving a linear model from the non-linear model structure;

- identifying a bias value for one or more input parameters and one or more output parameters;

- generating a dynamic spatial model of the one or more output parameters, wherein the one or more input parameters in a time domain relate to the one or more output parameters in a spatial domain;

- predicting one or more future output parameters when one or more test input parameters are provided to the linear model; and

- optimizing the one or more output parameters using the linear model.

35. The computer-readable medium of claim 34, wherein the dynamic spatial model is a deposition rate model.

36. The computer-readable medium of claim 34, wherein the one or more input parameters include:

one or more dopant gas flows including TriEthyl Borate, TriEthyl Phosphate, and TetraEthyl OrthoSilicate; and

one or more plasma etch inputs including pressure, power, and gas flows.

37. The computer-readable medium of claim 34, wherein the one or more output parameters include one or more chemical vapor deposition outputs including Secondary Ion Mass Spectrometry dopant profiles before and after reflow, Fourier Transform Infrared Spectroscopy aggregate dopant profiles, plasma etch outputs, and wet clean outputs including electrical measurements, critical dimension measurements, Scanning Electron Microscopy cross-section sidewall profiles before and after wet etch in both X and Y directions.

38. The computer-readable medium of claim 27, further having stored thereon computer-readable instructions, which when executed in the computer system, cause the computer system to perform manufacturing a semiconductor wafer with cell profile deviations less than 100 angstroms.

39. The computer-readable medium of claim 30, wherein the non-linear model structure is an INARX model, wherein the memoryless non-linear functions capture dynamic etch process behaviors.

## **ABSTRACT**

A method and system are disclosed for creating dynamic models of etch processes in semiconductor manufacturing. In one embodiment, a method comprises modeling an etch process used in semiconductor manufacturing to generate a dynamic process model. The dynamic process model is used to optimize process recipes by adjusting input values until the output values predicted by the model match the desired output values.